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A Comparison of Interactive Multimedia Instruction Designs Addressing Soldiers' Learning Needs

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14. ABSTRACT *(Maximum 200 words)*: This report is the third in a series of three, focusing on applying instructional design and tailored training techniques to address the Army Learning Model's (ALM) point of need concept. Here, results are presented from an experiment testing three variations of needs-focused interactive multimedia instruction (IMI) for two topic domains, one more familiar to learners, and one less familiar. The three IMI variations were familiarization, core/refresher, and tailored training. The content domains were Adjust Indirect Fire (less familiar to the target audience) and Conduct a Defense by a Squad (more familiar to the target audience). The IMI content targeted new squad/team leaders (i.e., E-4 Specialist/Corporal and E-5 Sergeant). The experiment was conducted with 91 Soldiers enrolled in the Warrior Leaders Course at Fort Benning, GA. All the IMI variations were associated with increased test scores on posttests, but Soldiers in the less familiar topic condition benefitted from tailored training IMI significantly more than Soldiers in the more familiar topic condition. Tailored training design features, such as diagnostic assessment and individualized feedback, may support learners with less prior knowledge in selecting content to target their learning needs, similar to what more knowledgeable learners may already do.

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A COMPARISON OF INTERACTIVE MULTIMEDIA INSTRUCTION DESIGNS ADDRESSING SOLDIERS' LEARNING NEEDS

EXECUTIVE SUMMARY

Research Requirement:

This is the third in a series of three reports on a research effort that (a) evaluated existing Army Combat Arms interactive multimedia instruction (IMI) for modification to address learners' needs (i.e., Blankenbeckler, Graves, & Wampler, 2013), (b) designed and developed six IMI exemplars to cover three variations of needs-focused IMI designs (i.e., familiarization, core/refresher, and tailored training) for two topics (i.e., Adjust Indirect Fire and Conduct a Defense by a Squad) (i.e., Blankenbeckler, Graves, & Wampler, 2014), and (c) experimentally evaluated the IMI exemplars with Soldiers' enrolled in the Warrior Leaders Course at Fort Benning, GA. This report is focused on the experimental evaluation of the IMI exemplars. Together, the three reports and the IMI exemplars address challenges the Army faces to improve warfighting capabilities through enhanced training using tailored distributed training and education, intended to prepare and support Soldiers' and Leaders' learning at their point of need (TRADOC, 2014).

IMI enables the Army to provide training to Soldiers when and where they need it (TRADOC, 2011), with content and instructional design to address Soldiers' learning needs. In addition, IMI provides a viable means to deliver training that is tailored to individuals' specific learning needs. Often, implementations of tailored or adaptive training in IMI are complex, requiring detailed statistical analyses, or are too costly to justify development for a small, narrowly-defined audience. However, there may be simpler yet equally effective ways to design IMI to address the learning needs of both a narrowly defined audience and individual learners, targeting what has been described in the Army Learning Model (ALM) as *point of need*. This research focused on experimentally testing three types of needs-focused IMI designs in order to determine which may be the most effective in addressing Soldiers' learning needs.

Procedure:

Six IMI exemplars were developed, focusing on three types of learners' needs, i.e., familiarization, core/refresher, and tailored training. Familiarization IMI focused content on breadth of information to help learners become familiar with a topic, and prepare them for additional learning. Core/refresher IMI content focused less on breadth and more on depth of information to support learners in executing a specific task. Finally, tailored training incorporated aspects of both familiarization and core/refresher in terms of content, including pre- and post-training diagnostic assessments with individualized feedback. The diagnostic assessment and individualized feedback was intended to assist Soldiers in selecting the most beneficial learning path for them among the various options made available. The familiarization and core/refresher IMI were non-tailored. Targeting new squad/team leaders (i.e., E-4 Specialist/Corporal and E-5 Sergeant), the two training topics selected were Adjust Indirect Fire (a topic less familiar to the intended audience), and Conduct a Defense by a Squad (a topic more familiar to the intended audience) (Blankenbeckler et al., 2014).

The IMI were tested in six sessions with 91 Soldiers enrolled in the Warrior Leader Course at Fort Benning, GA. Soldiers were administered a self-report questionnaire intended to estimate their background knowledge and experience with the respective topics. Their responses to the questionnaire were used to assign them to the three IMI conditions, balancing the level of knowledge and experience within each group. Soldiers were then administered a pretest to measure their level of knowledge before training. Following the pretest, they completed the IMI training. After IMI training was complete, they were administered a posttest of their knowledge. Finally, the Soldiers completed a questionnaire to evaluate their learning experience with the IMI, and a small number were briefly interviewed after turning in their questionnaire.

Findings:

Although we believed scores would increase for all IMI conditions, we hypothesized that Soldiers assigned to the tailored training IMI conditions would have the greatest increase in scores from pretest to posttest compared to familiarization and core/refresher. Additionally, we hypothesized that tailored training would be more effective for Soldiers receiving training on a less familiar topic domain (i.e., Adjust Indirect Fire) compared to a more familiar topic (i.e., Conduct a Defense by a Squad) because the tailored training IMI provided Soldiers with a diagnostic assessment and individualized feedback to assist them in more effectively selecting content on which to focus their effort.

As anticipated, there was a statistically significant increase in scores (i.e., 8 to 12 percentage points) across all IMI variations. However, in the more familiar topic domain, the tailored training IMI did not produce a significantly greater increase in scores compared to familiarization and core/refresher. In contrast, for the less familiar topic domain, there was a statistically significant 18 percentage point gain between pretest and posttest scores for the tailored training variation. This finding indicates that there may be some advantage in providing a diagnostic assessment and individualized feedback to Soldiers before training when they are learning about a topic with which they are less familiar. That said, in the more familiar content domain, design features shared across all IMI variations—such as chunked content—may have facilitated already knowledgeable Soldiers in tailoring their own learning experience regardless of IMI condition.

Utilization and Dissemination of Findings:

This report presents our findings from the final phase of the Tailoring Multimedia Instruction to Soldier Needs research effort. The results of the experiment were briefed to MCoE DOTD, 4 November 2013, were presented as an information paper to the Henry Caro Noncommissioned Officer Academy at Fort Benning, GA in December 2013 and to the Institute for Noncommissioned Officer Professional Development, March 2014. The results were also presented at the Interservice/Industry Training, Simulation and Education Conference in Orlando, FL, December 2014.

A COMPARISON OF INTERACTIVE MULTIMEDIA INSTRUCTION DESIGNS ADDRESSING SOLDIERS' LEARNING NEEDS

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

A Comparison of Interactive Multimedia Instruction Designs Addressing Soldiers' Learning Needs

INTRODUCTION

The Army Learning Model (ALM) has emphasized the need for instruction that is both tailored to career-specific and individual learning needs, and accessible to learners where and when they need it in a career-long continuum (TRADOC, 2011). In pursuing these goals, the Army has found computer-based interactive multimedia instruction (IMI) to be a cost-effective way to provide instruction to large audiences of learners. Moreover, IMI can also be designed to deliver instruction that targets the learning needs of particular audiences and individuals. Our research focused on the question of how to design IMI to best meet Soldiers' career-specific and individual learning needs.

This research report, which is the third in a series of three, documents an experiment conducted to evaluate three needs-focused IMI design variations for two content domains. Earlier phases of the research were presented in two previous reports (see Blankenbeckler, Graves, & Wampler, 2013; 2014). The 2013 report presented a survey of existing Army Combat Arms IMI (e.g., Infantry, Air Defense, Armor, and Field Artillery). This survey was conducted to identify whether and how existing IMI could be modified to various point of need focused instructional designs, targeting a particular audience with job-specific and individual learning requirements (i.e., Blankenbeckler et al., 2013). The 2014 report then described the process and rationale for developing six IMI exemplars, applying various principles of instructional design to address the learning needs of new squad and team leaders (i.e., Blankenbeckler et al., 2014).

The experiment documented in this report compared the effectiveness of three types of needs-focused IMI designs (i.e., familiarization, core/refresher, and tailored training) for training a particular population of Soldiers (E-4 Corporal/Specialist and E-5 Sergeants) on two topics, one more familiar to them (Conduct a Defense by a Squad) and one less familiar (Adjust Indirect Fire). The results of this experiment may be used to inform the planning and development of Army IMI focused on addressing the learning needs of specific audiences and individuals. Together, the three reports and the IMI exemplars address Army warfighting challenges to enhance training in areas of tailored distributed training and education, preparing and supporting Soldiers' and Leaders' learning at their point of need (see TRADOC, 2014).

Background on the Research Problem

Various characteristics of IMI work together to shape the learning experience both in terms of how the learning content is presented—audio, visual, textual—and how learners are able to interact with aspects of the instructional design. Interactivity can be as simple as a learner controlling how quickly they move through an IMI module to very complex implementations of adaptive or tailored training, intended to create individualized learning experiences. Although interactivity can be beneficial to learning, too much interactivity could compromise learning outcomes.

While there are many possible ways to design IMI, it has to be relatively self-contained and self-correcting. To contrast IMI with classroom instruction, an instructor in a classroom can help learners to recognize problems they are having and guide them in seeking effective solutions. This is more difficult in a distance learning situation which means IMI should be designed to assist learners in making reasonable decisions about how to pursue their learning objectives, even if they start out with little awareness of what they need to learn.

With the right information technologies in place, IMI can reach a diverse audience of learners. However, the IMI made available to this audience may not always address the varying knowledge, skills, and experiences represented among its members. IMI should be designed to address individual differences among learners, and to ensure that content aligns with career and professional development goals. The ALM recognized that Soldiers arrive for training with a variety of educational backgrounds and professional experiences, and these differences are reflected in different learning needs (TRADOC, 2011). Soldiers, as a consequence, require IMI that can address their individual learning needs as well as shared needs specific to their career path and career point.

Needs-Focused IMI Designs for Targeted Audiences

The Army has developed IMI that applies adaptive and tailored training techniques to address Soldiers' individualized learning needs (see review in Blankenbeckler et al., 2013). Some existing Army IMI has used high-bandwidth streaming video with a branching story structure, or complex algorithms to track and customize Soldiers' progress through the instructional content. Although a number of these IMI are of very high quality, they were likely expensive to develop. The expense involved in very complex design features may deter their use in IMI designed for smaller, more specialized audiences. For instance, implementing a technique like computer adaptive testing (CAT) requires data collected from a large number of participants. Without that sufficient pool of learners from which to gather data, the CAT technique would be inappropriate. Given the benefits of providing training tailored to Soldiers' unique learning needs, it is necessary to determine the validity of simplified tailoring techniques that can be applied in IMI intended for smaller audiences.

Our previous research explored IMI designs to address the learning needs of smaller, more specialized audiences (i.e., Blankenbeckler et al., 2014). In this research effort, we sought to empirically validate simplified tailored training techniques intended to address Soldiers' individual and career-specific learning needs. Three types of needs-focused IMI designs were used to design IMI for two topics. Both topics and content were selected to target the learning needs of new squad and team leaders (i.e., Specialist/Corporal, E-4 and Sergeant, E-5 levels). The training topics were Adjust Indirect Fire (Task #061-283-6003) and Conduct a Defense by a Squad (Task #071-430-0002) (U.S. Army, 2008). The three IMI designs included one tailored training variation and two non-tailored training variations, labeled familiarization and core/refresher.

Familiarization was a non-tailored IMI design, intended to provide a broad overview of content. Through familiarization IMI, the learner would acquire a coherent general understanding of the training topic without going into great depth. Much of the existing Army

IMI follows this design strategy (Blankenbeckler et al., 2013). The second non-tailored IMI design was core/refresher training, which focused on providing in-depth information on how to execute a specific task. As a result, core/refresher has less coverage of breadth information (i.e., contextual content) than familiarization. This design strategy was selected on the basis of discussion with MCoE DOTD, who expressed a need to utilize multimedia training designs that provide for rapid, in-depth refresher training. Finally, the tailored training design combined both the breadth of familiarization and the depth of core/refresher training into multiple, learner-selected training paths, each providing different content. In the tailored condition, a diagnostic assessment with individualized feedback was provided to learners before and after training to help inform their decisions to pursue a particular path through the instructional content. Rather than automated selection, learners selected their own instructional path from among those available. Of the three designs tested, two were non-tailored, and one was tailored; the two non-tailored designs differed in terms of the breadth versus depth of content covered whereas the tailored training design incorporated both depth and breadth of content.

Why Three IMI Variations: The Learner Autonomy Concept

A central concept in the ALM is that of learner-centered training. In learner-centered training, the focus is both on providing training that addresses individual learning needs as well as increasing the responsibility of learners for their own success. In the learning research literature, the concept of learner autonomy is associated with ongoing debate, but a widely cited definition refers to the “capacity to take control over one’s own learning,” with the goals of instructional institutions to improve learners’ ability to learn on their own and to facilitate access to required learning materials (Benson, 2011, pg. 2). However, simply providing learners with more materials they can use when learning on their own (i.e., using more distance learning technologies) does not necessarily lead them to become more autonomous learners. Therefore, the learning materials and selected content needs to be designed to facilitate the learners’ role in the learning process.

There are gradations of learner autonomy (see Benson, 2011). One can consider fully autonomous learners to be those who are selecting their own learning materials, pacing their learning process, self-assessing, and determining how to proceed throughout the learning process. While self-directed learning of this type is a very complex process, it may also be a widespread practice among adult learners in the Army (see Graves, Rauchfuss, & Wisecarver, 2012). Fully autonomous learning requires a learner who is already somewhat knowledgeable about a domain and has the requisite skills to plan and execute a self-guided learning process (Dickenson, 1987).

There are also situations in which it is appropriate for learners to be semi-autonomous. Instruction can be designed to structure the learning experience, but the learner can also be an active participant by selecting among available pathways through the learning content. Learning materials can be designed to guide learners during the learning process, even if learners are not yet knowledgeable about the domain or are not yet skilled at self-guided learning. The IMI we designed in this effort sought to address different levels of learner autonomy, with familiarization and core/refresher intended to support lower levels of learner autonomy and tailored training to support a higher level of autonomy.

Multimedia Design Decisions

Instructional designers create learning environments to promote learning, adjusting design strategies to varying levels of learner control and autonomy (Mayer, 2008). In doing so, they must determine how best to convey ideas, selecting among possibilities such as speech, written words, illustrations, charts, or videos (Mayer & Moreno, 2003). With each design choice, the designer determines what particular types of materials will be used and what is the best way to organize content (Mayer, 2008). For multimedia instructional design, it may be useful to think in terms of how language (written and spoken) and pictures may be most effectively used together for instructional purposes within a particular medium (see Bartholomé & Bromme, 2009; Mayer & Moreno, 2003). Moreover, it is useful to consider the ways in which learners make sense of multiple types of information being presented to them through multiple sensory modalities.

The purpose of IMI is to encourage learners to actively integrate information (Gyselinck, Jamet, & Dubois, 2008). For learners to actively integrate information, it is up to the instructional designer to make various segments of instruction work together, both in terms of spatial layout of text and images, as well as the sequence and timing of how information is presented. For instance, a designer could provide learners with information that is sequenced from familiar to unfamiliar. This approach may help learners build a more complex understanding by activating prior knowledge and providing a context for learning (Mayer, 2001; Mayer & Moreno, 2003). When instruction is designed in this way, learners may be better prepared to make meaningful connections between the concepts they are learning and what they already know. Moreover, by making prior knowledge salient before introducing new concepts, learners may also be better positioned to recognize general principles that could support transfer of what they learned to other contexts (Mayer & Moreno, 2003).

Research has suggested that IMI is effective due to particular design choices and the degree to which learners are encouraged to actively shape their learning experiences (Lusk et al., 2009). Planning for interactivity is important, and can be as simple as allowing learners to control how quickly they progress through the materials (Mayer & Chandler, 2001). Designing IMI to support varying degrees of learner autonomy may have benefits for learning outcomes (Mayer, 2008).

Instructional Design Principles and IMI

Organizations recognize benefits from IMI, such as being able to reach a large audience with compelling learning materials, centralizing control of learning materials, and cost savings from bringing the learning environment to the student rather than the student to the environment (Fletcher, 2009). Like any form of instruction, however, quality is ultimately determined by content selection and careful design. Instructional design needs to support learners in making sense of what they are learning. This recognition has motivated research on the ways in which instructional design intersects with human cognitive processes, focusing on topics such as how learners perceive and make sense of relevant information, remember critical information, or apply what they learned to solve problems and make decisions (Schüler, Scheiter, & van Genuchten, 2011).

Researchers have experimented with various instructional design features (e.g., highlighting text, structure of content, or varying communication style) and compared the learning outcomes. They have prescribed guidelines to use when designing IMI (see Clark & Mayer, 2008). Mayer (2005) has argued that the most effective instructional designs reduce irrelevant information and help learners to think more deeply about the training content. This is done by (a) reducing extraneous cognitive processing, (b) managing essential cognitive processing, and (c) facilitating generative processing.

To reduce extraneous cognitive processing, instructional designs should remove distracting information and emphasize critical information. This can be done through careful selection of words and images, offsetting or highlighting critical ideas, avoiding putting too much information in one place, using visual space logically, and pacing instruction carefully. Applying these techniques may help learners to identify relevant content on which to focus their time and effort.

To manage essential cognitive processing, the instruction should be designed to help learners make sense of what they are learning. This design goal focuses on interrelated principles that allow learners to self-pace their learning, make use of preexisting knowledge, and reduce conflicts between sensory modalities. For example, a designer should avoid presenting animations along with static text because both require learners' visual attention.

Finally, to facilitate generative processing design features should be incorporated to support learners in achieving a deeper understanding of the material they are learning. The goal is to reduce as much as possible any barriers to understanding by establishing an appropriate communication style with a learner (see Clark & Mayer, 2008; Mayer, 2009; Moreno & Mayer, 2007). Table 1 presents various design features and how they have been applied in IMI.

Contributions of Cognitive Psychology to Instructional Design

A scientific understanding of human learning capabilities and needs should set boundaries for instructional design (Tardieu & Gyselinck, 2003). All learners have capacities that limit how much and how quickly they can perceive, attend to, understand, recall, and use newly acquired information. Learners also differ in terms of their mental abilities, background experiences, and prior knowledge. Bearing this in mind, IMI must be designed to support learning within these normal human limitations. Research in cognitive psychology—which looks at how human beings think, remember, plan, decide, problem-solve, and learn—provides a useful account of the ways in which learners can differ. By focusing on human cognition, one may find a way toward more effective instructional designs.

Table 1
IMI Design Features and their Application

Goal	Features	Application
To Reduce Extraneous Cognitive Processing	Coherence	Eliminating extraneous words, pictures, images
	Signaling	Highlighting important words (e.g., section headings, highlighting, boldface font)
	Redundancy	Combining animations with narrations rather than animation, narration and text
	Spatial Contiguity	Placing corresponding portions of pictures and words near each other
	Temporal Contiguity	Presenting corresponding animation and narration simultaneously rather than successively
To Manage Essential Cognitive Processing	Segmenting	Presenting narrated animation in learner-paced segments
	Pre-training	Providing pre-training in vocabulary and key concepts (e.g., outlines, key learning objectives, bottom line up front)
	Modality	Combining animation (visual) with narration (auditory), not animation (visual) with text (visual)
	Guided Activity	Prompting learners to select, organize, and integrate new information
	Reflection	Encouraging self-reflection to activate organization and integration of new information
	Feedback	Providing learners with proper schemas to repair misconceptions
	Worked Examples	Leveraging worked examples to show how to work though tasks/problems step-by-step
To Encourage Generative Processing	Personalization	Communicating in an informal/conversational style
	Voice	Narrating in a non-accented voice rather than a machine-simulated voice
	Pacing	Allowing learners to control their pace, and process smaller chunks of information in working memory
	Sequencing	Ordering information to move from old (familiar) information to new (unfamiliar) information
	Clear Structure	Using a familiar structure/pattern for presenting information (e.g., compare-contrast, classification, enumeration, cause-effect)

Note: Table adapted from Blankenbeckler et al. (2014).

Working Memory

Memory is an essential cognitive process for learning. Being able to remember is one way we intuitively determine whether we have learned. Cognitive psychologists have shown, however, that remembering is a complex process with many limitations. Evidence suggests that there may be several memory systems involved in how we learn. For instance, one well-known model identifies three interacting memory systems: auditory, visual, and executive (see Baddeley & Hitch, 1974). In emphasizing the role of the executive system, this model of memory suggests that getting information into memory is more than a matter of just repeatedly encountering it. Information needs to be encoded in such a way that it is meaningful to learners. This encoding process is particularly important for adult learners, who bring far more contextual knowledge and experience to the learning situation compared to children. By understanding what the audience likely already knows, designers can plan how they will introduce new knowledge by making effective use of these different memory systems.

Attention

Attention is another cognitive process important for memory. How we attend to what we see and hear can affect how we later remember it (Baddeley, 2000). Attention can be consciously controlled. Even though our immediate auditory and visual memories have a very brief span, they do retain information long enough that we can begin to make sense of what we have perceived (Sperling, 1960; Neisser, 1967). For instance, consider the experience of someone unexpectedly talking to you while you are concentrating on another task. You may hear sounds, but it is only after you shift your focus to those sounds that it may take an additional second or so before you understand what was said. That shift in attention is possible because auditory memory can retain the sounds of the words that were spoken in a raw state, even though you were not paying attention to them. Auditory memory tends to be longer (2 to 4 seconds) than visual memory (less than 1 second), however, both systems function to hold raw information long enough that we can make sense of it. In experimental psychology, a common laboratory task is to have research participants learn information with other information present to distract them and interfere with the learning process. While interference is excellent for isolating mental processes in a laboratory, it detracts from instructional design. One should consider the types of actions the learner is being asked to take when interacting with the media, such as searching for information or making mental calculations, and avoid conflicts in what learners are being asked to pay attention to (Gyselinck, Ehrlich, Cornoldi, de Beni, & Dubois, 2000).

Cognitive psychology can inform the work of instructional designers. It provides a way to understand why certain types of multimedia instructional designs may be more effective or less effective for learning. When engaged in multimedia learning, learners have to integrate both visual and auditory information into a coherent message (Reed, 2006). If the information is being presented too quickly, or through too many modalities, the executive function of memory can become overwhelmed. When this occurs during learning, learners will either slow down or begin to miss critical information, limiting their ability to make sense of the content and connect it with information they already know.

Moreover, how information is processed through different sensory modalities should be considered. Some research suggests that there is benefit to receiving information through different sensory modalities, as long as it is not being presented simultaneously to the same or similar modalities (Clark & Paivio, 1991). For instance, when reading text, some people will *hear* the words they are reading; others may make sense of the words in terms of what they are seeing (see Schüler et al., 2011). Whether we hear or see words while reading implies that different memory systems may have been called on to process that information. For learners who *hear* as they read, the narration within IMI—if it is presented with visual text—can hinder their ability to understand. The same memory system is receiving two potentially conflicting streams of information thereby forcing the executive system to focus on one stream of information, or else both may become jumbled together (Baddeley, 1986; 2000). This suggests that careful sequencing of new information relying on different modalities may be useful in reducing cognitive processing conflicts and support learners in forming a coherent understanding of what they are learning (Bruner, 1990).

Extrinsic, Intrinsic, and Germane Cognitive Load

Cognitive load describes the mental effort expended by working memory, and may provide a framework for understanding how cognitive processes and instructional design are related (Paas, Renkl, & Sweller, 2003). Cognitive load theory enables researchers to identify sources of load imposed during learning, and determine how these sources of load may interact to influence learning outcomes (Schüler et al., 2011).

There are three types of sources for cognitive load: extrinsic, intrinsic, and germane load. Extrinsic load arises from the structure and complexity of the learning materials (Brünken, Plass, & Leutner, 2003). For instance, poorly designed IMI may impose unnecessary extrinsic load because of its inherent structure and not due to the difficulty of content (Paas et al., 2003). However, the imposition of extrinsic load can be well-intentioned. Presenting written text that is verbatim to narrated content—a misguided, yet common practice—can at times impose unnecessary load by splitting learners' attention (Mayer, 2001). Repeating information in multiple presentation modalities is often unnecessary if learners are afforded the option of replaying sections of narration. Therefore, IMI instructional designs should focus on reducing extrinsic load as much as possible to support efficient learning.

Intrinsic load refers to the cognitive effort required to integrate new information with prior knowledge (Moreno & Park, 2010). It is far more difficult to reduce intrinsic load as effectively as extrinsic load because some content domains are more difficult to learn. The difficulty of content can affect instructional designers' ability to reduce intrinsic load, especially for learners who are new to a content domain. However, one of the ways to reduce this load is through application of tailored training principles that can help to shape instruction to individual learners' prior knowledge and experience (Pass et al., 2003; Spanjers, Wouters, van Gog, & van Merriënboer, 2011).

That said, for learners who are more familiar with a content domain, their preexisting understanding of that domain can reduce their intrinsic load while learning. Having prior knowledge and experience may help to improve integration of new information for learners who are familiar with a domain. Moreover, by having a reduced intrinsic load, learners who are familiar with a domain may be better positioned to address extraneous sources of load (Khacharem et al., 2013; Spanjers et al., 2011). In other words, learners familiar with a domain may more effectively use learning materials of varying complexity and quality than learners who are less familiar with a domain.

Finally, germane load refers to cognitive resources that the learner focuses on to construct a mental model and understand the content domain (Sweller, 2010). For instance, by providing well-structured and well-organized training, with clearly labeled sections and subsections, the learner may be exposed to a coherent structure of the domain. This ordered structure could help them organize information in a way that will be effective for them in developing a mental model. In addition, tools to assist learners in planning in advance how they will work through the content can mitigate difficulties they might otherwise encounter while learning from complex materials.

Prior Knowledge and Experience

Prior knowledge and experience may strongly affect how well a learner can learn from a particular IMI, even when design features have been incorporated to mitigate sources of cognitive load (Brünken et al., 2003; Kalyuga, Ayres, Chandler, & Sweller, 2003). One example of this is the expertise reversal effect. The expertise reversal effect occurs when certain training designs and content selections may be associated with decreased performance for knowledgeable learners. From a design standpoint, the effect is typically associated with too much basic information being provided to learners who already have a strong understanding of the domain (Kalyuga, 2009). Some instructional designs appropriate for learners with less prior knowledge become inappropriate as learners become more knowledgeable in a domain, especially when designs lockstep advanced learners through basic content (Kalyuga & Renkl, 2010). Therefore, when possible, it is advantageous to evaluate the prior knowledge of target audiences, using techniques like front-end or needs analysis, before designing IMI in order to a) promote learning and b) avoid wasting time and resources pursuing a potentially ineffective design strategy (see Yardakul, Uslu, Cakar, & Yildiz, 2014).

Applications of Effective Design Principles

A number of IMI design concepts arise from a scientific understanding of working memory, attention, cognitive load, and prior knowledge and experience. The following design principles can be incorporated into IMI to increase learner engagement and to facilitate learner autonomy, and include the multimedia principle, modality principle, redundancy principle, segmentation principle, and signaling/cueing.

Multimedia Principle

Fundamental to IMI is the idea that learning is more effective when information is presented in multiple formats. That is, learners may learn better from combinations of words and pictures than from words alone. Research has indicated that IMI that encourages learners to connect different sources of information tends to be more effective (Mayer, 2002). Most multimedia learning environments combine text and pictures (Bartholomé & Bromme, 2009). These may range from using imagery from static stills (i.e., diagrams, charts, photos, etc.) to dynamic animations (Mayer, 2011). Images can encourage in-depth processing by providing ready visual representations of spoken or written words (Larkin & Simon, 1987), reducing cognitive load (van Genuchen, Scheiter, & Schüler, 2012) and supporting learners in making inferences about what they are learning (Schmidt-Weigand & Scheiter, 2011). Incorporating text and pictures can encourage better integration of new information with prior knowledge (Mayer, 2002; 2008). Finally, pictures and diagrams may be beneficial for learning procedural tasks (van Genuchen et al., 2012), that is, tasks which have goals that can be achieved by executing a series of specific actions.

Modality Principle

Learners process visual and verbal information with separate cognitive systems (see Baddeley, 1992; Paivio, 1986). Presenting too much information, either verbally or visually, can overload learners' information processing capabilities (Brünken, Plass, & Leutner, 2003). Therefore, when incorporating the multimedia principle into designing IMI, designers may benefit from also applying the modality principle to reduce cognitive load. Research has indicated that learners are more successful when learning from animations paired with narrations over presentations comprised of static text with on-screen images (Moreno & Mayer, 1999). Presenting static text with on-screen images may split attention between relevant sources of information presented visually (Schüler, Scheiter, Rummer, & Gerjets, 2012; Mousavi, Low, & Sweller, 1995). Therefore, narrations are beneficial because they enable the learner to attend to the visual information while also processing audio content, thereby reducing conflict between these different information processing systems (Gyselinck et al., 2008; Kalyuga, Chandler, & Sweller, 2000). Narration with images enables learners to process complex information simultaneously; whereas, text with images requires sequential processing (Rummer, Schweppe, Fürstenberg, Seufert, & Brünken, 2010).

Redundancy Principle

While incorporating redundant information into lessons may facilitate learning because it provides multiple opportunities to learn content (Mayer, 2001), it can also impair learning by violating the modality principle (Mayer, Heiser, & Lonn, 2001). In one study, students who viewed narrated animations with concurrent visual text performed significantly worse than students who viewed only narrated animations (Mayer et al., 2001). If it is necessary to include redundant information within IMI, adding a few redundant words from a narration and presenting them visually can improve learning as long as the redundant information is short, highlights essential concepts, and is presented in close proximity to the portion of the graphic/animation being described (Mayer & Johnson, 2008). Novices may need more guidance when learning and can benefit from redundant on-screen texts, whereas experts may find it distracting, especially when they cannot navigate around the redundancies (see Kalyuga et al., 2003).

Segmentation Principle

Long sections of training can impose a higher cognitive load (Mayer & Moreno, 2003). To reduce this load, segmentation has been proposed as a useful instructional principle that can be employed to divide longer, continuous instruction into shorter segments (Cheon, Crooks, & Chung, 2014; Mayer & Moreno, 2003). By presenting less content per segment, learners may be better able to process materials without experiencing too much cognitive load. Although learners can benefit from system-controlled segmented presentations (Spanjers et al., 2011), learners benefit more when they control the pace of animations (i.e., segmentation principle; Mayer & Chandler, 2001). Designing IMI to incorporate segmentation requires instructors to divide multimedia tutorials into segments (Doolittle, 2010). At the end of each segment, the animation stops. At that point, the learner then decides when to advance to the next segment by clicking a "continue" button. By allowing learners to set their own pace of learning, segmentation helps create a more interactive learning environment and may promote a better transfer of learning (Mayer, 2002).

Signaling/Cueing

Learners can sometimes have difficulty identifying salient information (Boucheix, Lowe, Putri, & Goff, 2013). The more complex an IMI presentation becomes, the more selective the learners tend to become in what they pay attention to (Betrancourt, 2005). Novice learners tend to focus on perceptual content that may or may not be relevant (Boucheix et al., 2013). Visual cueing can be an effective way to get learners to attend to critical information (Lin & Atkinson, 2011) by guiding them without adding to their cognitive load (Mayer & Moreno, 2003). Changing colors or emphasizing critical text has been shown to improve immediate comprehension (Boucheix & Guignard, 2005). Likewise, using diagrams with color and arrows to visualize technical concepts also produced an increase in learning (Huk, 2006). However, cueing may not always lead to better learning outcomes (Kriz & Hegarty, 2007). Cues are most effective if not obscured by overly complex graphics or animations, and if learners need such cues to support their learning (de Koning et al., 2009). If cues are overused, learners' attention can be divided, compromising learning outcomes (Moreno, 2007).

Summary of Design Principles

The following points summarize recommendations from the literature concerning how to optimize IMI design to address learners' needs:

- When designing and developing IMI for specific audiences, it is important to clearly define up-front what learners should be able to do after instruction. Integral to this process is determining the baseline levels of knowledge and experience possessed by the target audience.

- Connecting content with the knowledge and experience of a particular audience enables the designer to incorporate elements of real-world tasks and missions into the IMI content in order to create links to what learners will be expected to do when applying what they have learned. Providing varied examples and problems, with progressive levels of complexity and reduced assistance as learners become more familiar with the content helps to maintain their independence, motivation, and interest.

- Learners may benefit from being provided individualized performance feedback and tailored remediation.

- It is beneficial to provide content to learners in smaller logical chunks. Segmenting the content into learner-paced sections helps the learner to manage their cognitive load by giving them control over the pacing of instruction without overloading their ability to remember what they are learning.

- Providing learners with pre-training, covering key concepts and vocabulary, can be helpful to ensure they have requisite knowledge.

- It is easier for a learner to make sense of spoken words rather than text; however, the speech style of the narrator should be intelligible to a broad audience, and use a conversational style. It is better to use a human narrator rather than a machine voice.

- When laying out the content on the screen, it is important to highlight only the most critical information to ease the learning experience. Combining on-screen text with narrated animation can be confusing to learners. When presenting text with static images, the text should be placed close to the image it describes.

- When narration is used to describe animation, the two should be synchronized.

- Finally, it is important to provide individualized feedback to learners, such as providing a diagnostic assessment to support remediation prior to training or determination of an individualized learning path. Assessments can also be provided en-route, following chunks of training or sections that cover critical skills. An end of training assessment can be useful to determine one's level of proficiency or to identify re-training needs.

Emphasizing learner-centered and life-long learning initiatives, the ALM views IMI as essential to delivering instruction *where*, *when*, and *how* it is needed (TRADOC, 2011). For IMI designers to ask *where* the IMI will be used focuses them on the accessibility afforded by various learning technologies. Asking *when* it will be used focuses on the life-long learning needs of a target audience. Asking *how* it will be used focuses on the needs of individual learners. The current research specifically focused on the *when* and *how* questions—i.e., content selection and instructional design. Further, the impact that different technologies have on delivering IMI at the point of need is recognized. The current research was focused on exploring how instruction can be designed to meet the individual learning needs of new Noncommissioned Officers (NCOs) as they are preparing to become squad or team leaders. This current research compared variations in needs-focused IMI instructional design and different types of content selections to target the needs of a specific audience of learners.

METHOD

Three needs-focused IMI designs were compared for two topics related to Combat Arms. One topic was more familiar to learners (i.e., Conduct a Defense by a Squad), and one topic was less familiar (i.e., Adjust Indirect Fire). The selected IMI instructional content targeted the learning needs of new squad/team leaders (E-4 Specialist/Corporal, and E-5 Sergeant ranks). The IMI were experimentally tested with Soldiers enrolled in the Warrior Leader Course at Fort Benning, GA.

Materials

In developing the six IMI exemplars for the experiment, the researchers made use of some existing Army IMI collected during the first phase of this research (see Blankenbeckler et al., 2013 for a more detailed discussion), but for the most part developed new content. Existing IMI material had been collected from the Directorates of Training and Doctrine at the Maneuver Center of Excellence (Fort Benning, GA), the Fires Center of Excellence (Fort Sill, OK), and the Iowa National Guard Distributed Learning Development Center (Camp Dodge, IA). Also collected were examples of IMI from the Army Knowledge Online My Training Tab (MT2) site.

Parts of the existing IMI were selected to be reused in the experimental IMI according to the following criteria: (a) the content suitable for the intended audience, i.e., new squad or team leaders, (b) the original source files were available and editable, (c) source materials were compatible with current software available to modify files, (d) the concepts, uniforms, equipment, and materials depicted were current, and (e) the instructional design characteristics of the existing IMI were compatible with the planned modifications (e.g., content selection; quality of graphics, animation, text, and narration; navigation/organization).

Initially, the researchers had intended to produce exemplars of needs-focused IMI based entirely on existing content. Ultimately, only 30% of the existing materials were reusable in the way intended (see Blankenbeckler et al., 2013). Most of the existing IMI lacked source files that could be modified or had been designed in superseded versions of software. In addition, much of the existing IMI was designed to address a general audience, lacking the details necessary to focus content on squad or team leaders' specific learning needs. Our experience was similar to that reported by other Government and private sector organizations (see Shanley, Lewis, Straus, Rothenberg, & Daugherty, 2009).

Topic and Content Selection

After reviewing existing IMI, two topics were selected on which to design six IMI exemplars: *Adjust Indirect Fire* (Task #061-283-6003) and *Conduct a Defense by a Squad* (Task #071-430-0002) (U.S. Army, 2008). Given the emphasis of the MCoE initiative *Squad as the Foundation of the Decisive Force*, the two topic domains were selected because of their relevance to new squad and team leaders in combat arms specialties (Maneuver Center of Excellence, n.d.). Table 2 describes the six IMI exemplars in relation to the two topic domains.

Given that the target audience was new squad or team leaders (i.e., Specialist/Corporals, E-4, and Sergeants, E-5), it was anticipated that Conduct a Defense by a Squad would be more familiar to Soldiers because it is a common task in which Soldiers at varying levels participate, even if they are not yet in the role of decision-makers or leaders. In contrast, it was anticipated that Adjust Indirect Fire would be less familiar to Soldiers because it is a more complex topic, with specialized training requirements.

Table 2
Six Point of Need IMI Exemplars by Topic, Type of IMI, and Title

Topic	Type of IMI	Title
Adjust Indirect Fire (Task #061-283-6003)	Familiarization	Engaging Targets with Supporting Fires
	Core	Conduct Immediate Suppression
	Tailored Training	Adjust Indirect Fire
Conduct a Defense by a Squad (Task #071-430-0002)	Familiarization	Prepare Positions for Crew-Served Weapons During an Urban Operation
	Core	Designate and Prepare Urban Fighting Positions for a Javelin Team
	Tailored Training	Conduct a Defense by a Squad in an Urban Operation

Note: The tasks, conditions, and standards for the selected topics are documented in the *Soldier's Manual of Common Tasks, Warrior Leader Skills Level 2, 3, and 4* (U.S. Army, 2008).

Three Variations of Needs Focused IMI

The three types of training—familiarization, core/refresher, and tailored training—were selected to cover a variety of training needs from preparation for a course, acquiring background knowledge to support more in-depth study, supporting execution of tasks on the job, etc. Familiarization and core/refresher training were not tailored, whereas the tailored training condition was designed to facilitate learners in selecting an individualized learning path.

Familiarization. Familiarization training was intended to provide learners with an overview of the topic and resources to learn more (i.e., breadth of information). It would assist learners in gaining a modest understanding of the topic domain, but not a high-level of proficiency or expertise. Familiarization IMI was further intended for learners who need to be prepared for subsequent and more in depth learning, assisting them in forming a basic understanding of the content domain. Based on a previous survey of Army Combat Arms IMI, it was found that familiarization is the most common design used (Blankenbeckler et al., 2013).

Core/Refresher. Core/refresher training was intended to provide only the essential information learners would need to perform a defined task (i.e., it provided depth of information, with less breadth). When designing core/refresher IMI, the model was 'how-to' manuals that present step-by-step procedures of how to execute a task. Again, given that the focus was on learners' immediate needs, they were not intended to reach a high-level of proficiency. Core/refresher IMI was designed for learners who would need immediate support in conducting on-the-job tasks or a quick refresher of a previously learned skill. This type of training was not intended to lead to mastery of the task, as the core/refresher IMI contained no hands-on performance or sophisticated simulation. This variation was selected based on discussion with stakeholders at MCoE DOTD, who expressed a need to explore IMI designs that would support rapid, in-depth refresher training.

Tailored Training. Tailored training combined both breadth and depth of information into multiple user-selected learning paths while also providing increased learner autonomy over the familiarization and core/refresher variations. It also included pre- and post-training diagnostic assessments with individualized feedback following each assessment. Feedback to learners was based on a pre-training diagnostic assessment. The feedback was intended to help learners identify content areas in which they were deficient and to select among the available learning paths. After learners completed training, they were again administered a diagnostic assessment and received feedback, giving them the option for additional training. The tailored training design was intended to meet a variety of learning needs. The diagnostic assessments were intended to help learners to be more aware of their specific learning needs and to make reasonable decisions on how to tailor their learning experience. While this approach to tailoring did not make use of cutting-edge technologies (such as computer-adaptive testing), it represented an effective and low-cost solution to enable tailored training in Army IMI. This IMI design was selected to support objectives described in the Army Learning Concept, which focus on developing and delivering training that can address Soldiers' specific learning needs (TRADOC, 2011).

Design Principles Applied in the IMI

In designing the IMI exemplars for the experiment, configurations of design principles were applied. One design feature shared across the different types of IMI was content chunking. Content chunking is a design strategy that breaks up content into smaller parts that can be more readily learned, related to Miller's (1956) research on the limitations of human short-term memory. We chunked content in terms of whole tasks and parts of tasks (see Figure 1).

Content chunking allowed the researchers to present an organized structure to the learner up-front, as well as consolidate closely related material into manageable parts, helping to manage cognitive load (Sweller, 2005) and reduce extraneous processing (Mayer, 2005). In the example presented in Figure 1, content is being initially sorted into two general categories—i.e., Call for Fire, and Subsequent Corrections. Within each of these sections, content was further chunked so that training content would be presented in short, easily completed sections. This chunking structure was intended to facilitate learners in navigating through the IMI, serving as a way to organize content for the less knowledgeable Soldiers or as a road-map for the more knowledgeable. While chunked content was not intended to increase learner autonomy, the section headings could be used by some learners to navigate around portions of content.

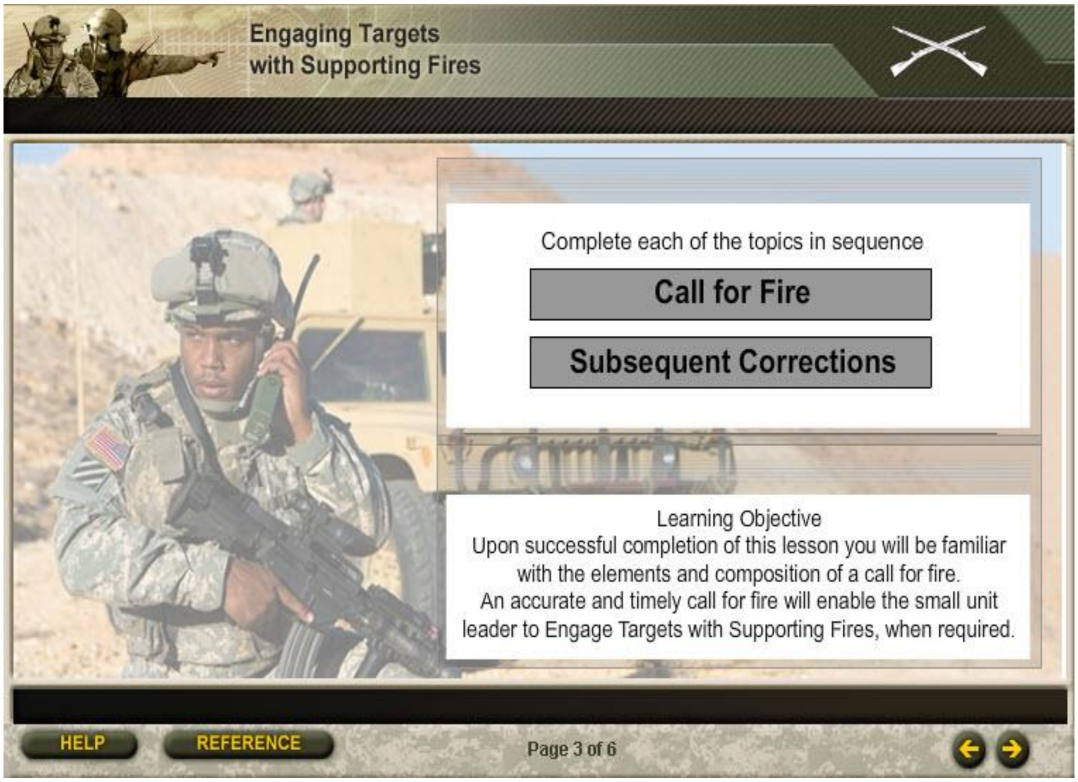

Figure 1. Example of Content Chunking

Making sure the instruction had a narrative pattern, presenting a clear sequence of steps to interconnect parts of the tasks, was also an important design principle (Clark, 2005). This approach was particularly useful for the core/refresher variations of needs-focused IMI. For example, questions and feedback followed the sequence of an Adjust Indirect Fire mission to summarize the Call for Fire and Fire Direction Center (FDC) responses (see Figure 2).

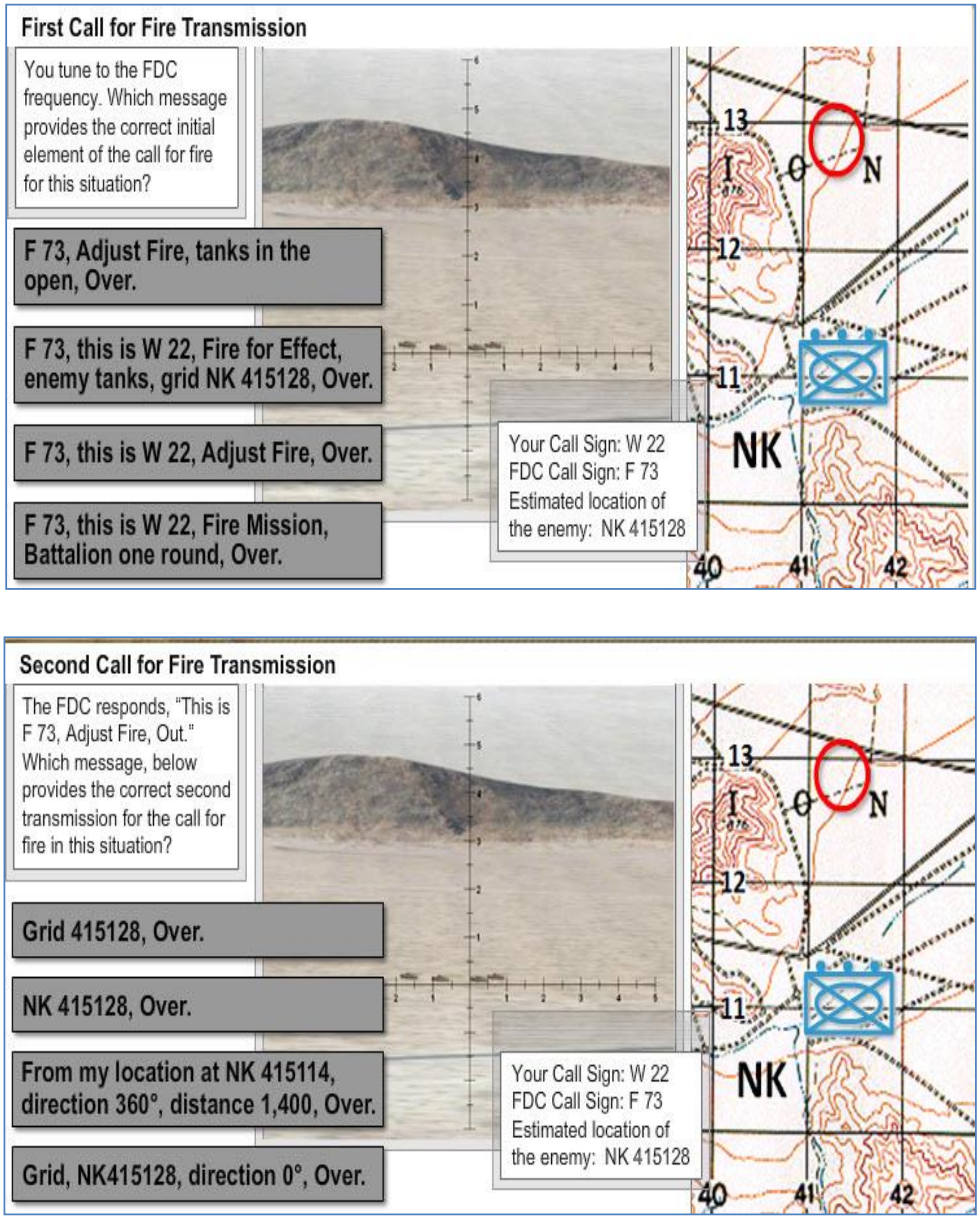

Figure 2. Example of Narrative Flow

Evaluation and feedback on specific task steps was also expected to help guide learners through the learning process, and served as a particular way of implementing narrative sequencing (see Figure 3). This approach helped learners to test their knowledge throughout the training and to maintain their focus on relevant content. This was viewed as an alternative way to approach 'checks-on-learning'[1] and was intended to maintain focus on the sequence of task

[1] Many examples of existing Army IMI used a checks-on-learning design pattern. They would present three to four pages of learning content, then present questions on that brief section of content. Often, the feedback provided concerned whether the learner had answered correctly or incorrectly.

execution. The learner received and responded to questions for each step in the task as it built in complexity. They were presented feedback on their decisions between steps, building toward the complete task (van Merriënboer & Kester, 2005).

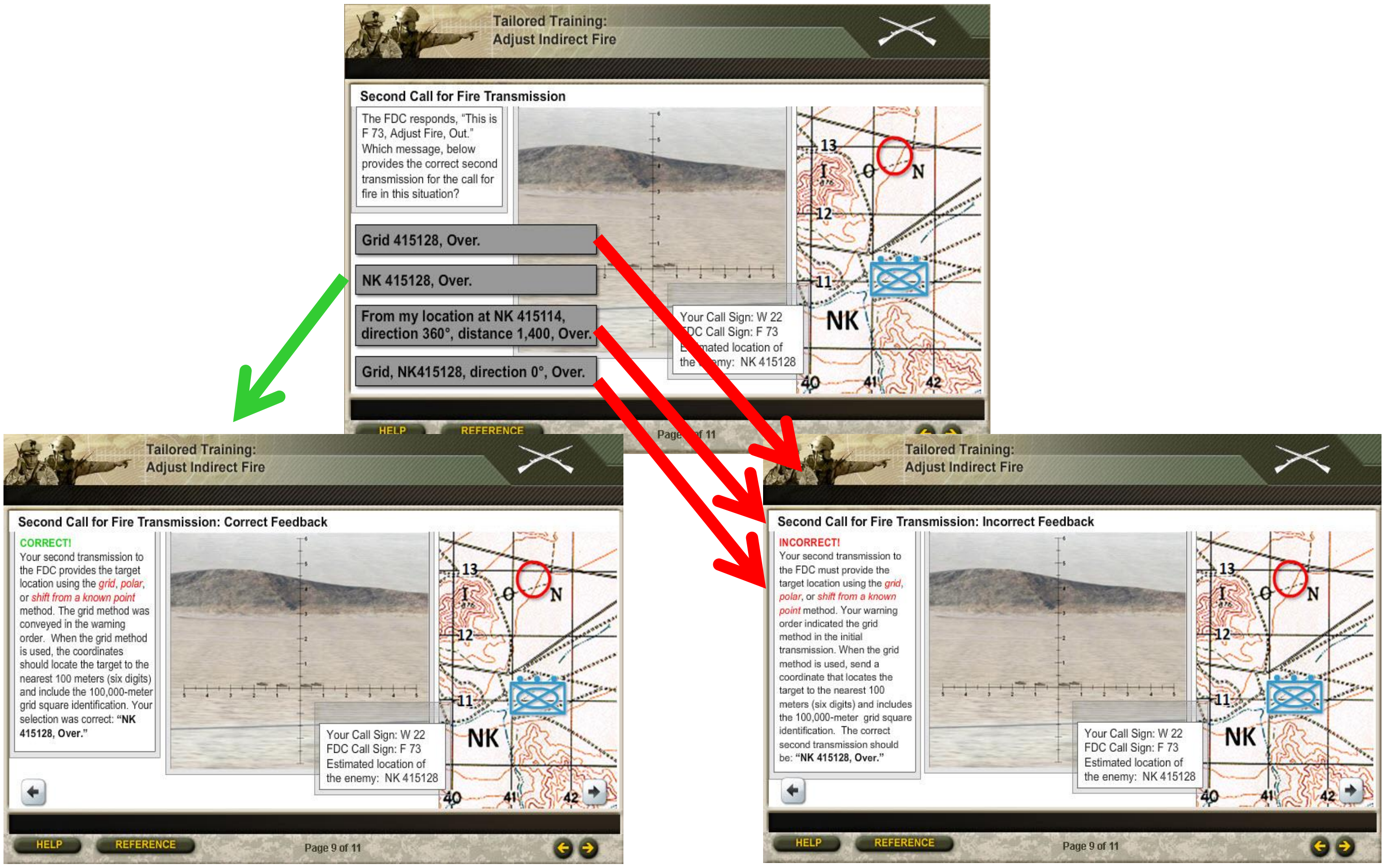

Figure 3. Example of Questions and Feedback on Individual Task Steps

Finally, the tailored training variation of needs-based IMI had some of its own unique features to support increased learner autonomy. For instance, whole task evaluation and feedback was unique to this variation. The tailored training IMI was designed with a diagnostic assessment at the start. This pre-training diagnostic was designed to measure prior knowledge learners had concerning the content domain and provided feedback to learners on their deficiencies. It was structured such that learners would receive individualized feedback and recommendations for particular content areas that they should focus on in training. Learners were allowed to select the content they wanted learn, although the recommendations were intended to help them to optimize their self-selected learning path. Training recommendations were made in relation to the structure of chunked content within the IMI, enabling learners to identify how to navigate through the content. This simple approach enabled the researchers to adapt training to learners' needs without employing a complex learning management system, as the learner ultimately determined how they would proceed through the IMI. Once the IMI was complete, learners were again given an opportunity to test their knowledge and were provided with additional feedback to help guide their selection of future learning (see Figure 4).

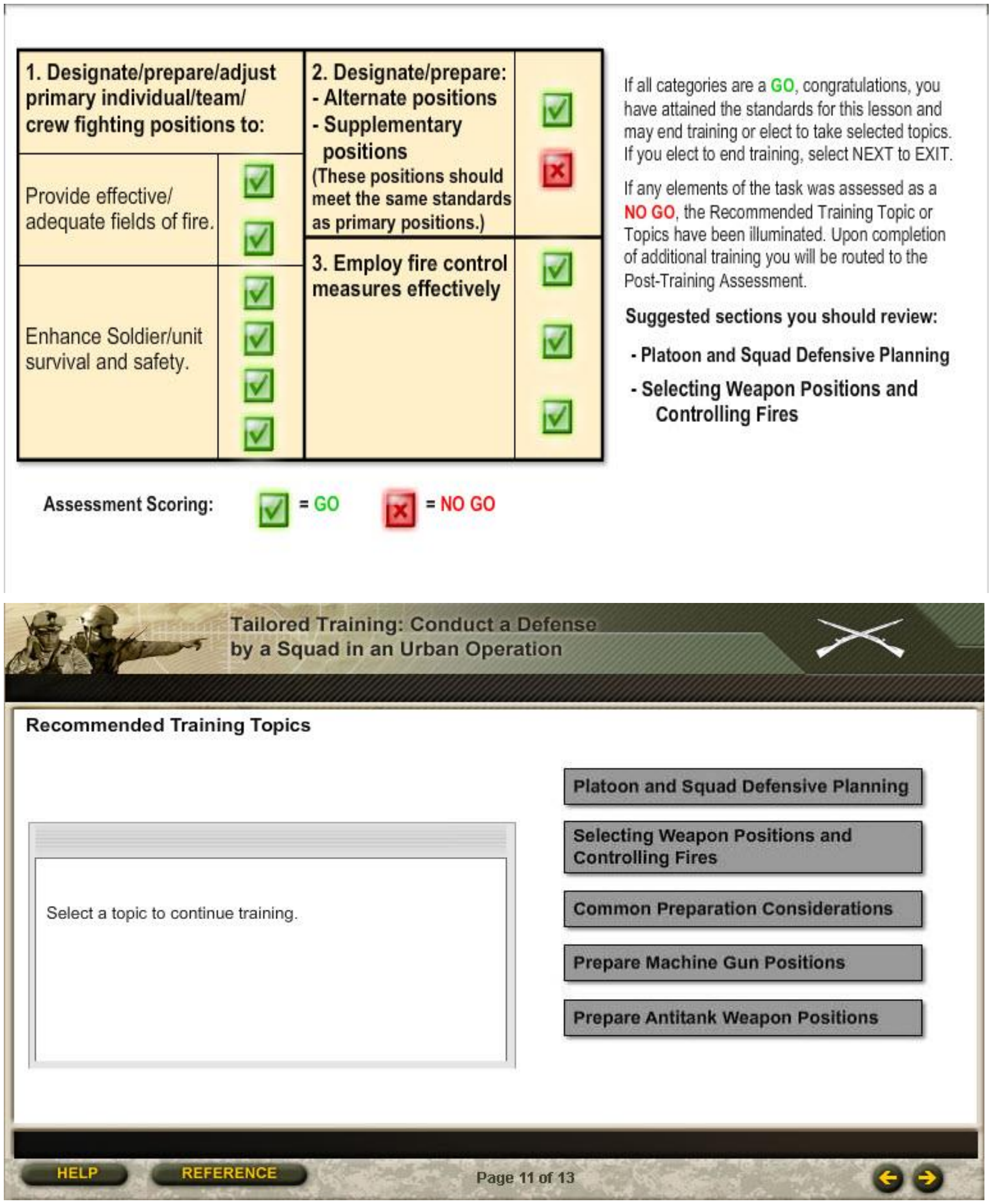

Figure 4. Example of Whole-Task Diagnostic Assessment and Feedback in Tailored Training Condition

Experimental Evaluation of the IMI

The IMI were experimentally tested with 91 Soldiers enrolled in the Warrior Leader Course (WLC) at the Henry Caro Noncommissioned Officer Academy at Fort Benning, GA. The experiment was designed to test the three variations of needs-focused IMI across the two topic domains. One domain was more familiar (i.e., Conduct a Defense by a Squad) to Soldiers and the other was less familiar (i.e., Adjust Indirect Fire). The three types of IMI tested were familiarization, core/refresher, and tailored training. Familiarization and core/refresher were non-tailored IMI variations, whereas the tailored training IMI incorporated design features to address individual learning needs.

The IMI were tested in six two-hour sessions. All three IMI variations were tested in each session with between 15 to 19 Soldiers enrolled in WLC. No Soldiers participated in more than one session. At the start of a session, the Soldiers were briefed on the purpose of the research and administered and signed the informed consent form. They were then asked to complete a short demographic questionnaire and to rate their familiarity with the selected training topic for that session, described broadly as either Adjust Indirect Fire or Conduct a Defense by a Squad. Based on their ratings, Soldiers were assigned to one of the three IMI conditions: familiarization (n = 29; 32% of Soldiers), core/refresher (n = 29; 32%), or tailored training (n = 33; 36%). A self-rating assessment of prior knowledge about the topic was used to balance assignment of Soldiers. Based on self-ratings of prior knowledge, Soldiers who rated themselves 1 to 3, 4 to 6, or 7 to 9 on the prior knowledge scale were sorted respectively into three groups. From these three groups, Soldiers were assigned to a specific IMI variation, balancing prior knowledge across each variation. Soldiers who participated were Specialists/Corporals (E-4, n = 61; 67%) and Sergeants (E-5, n = 30; 33%), and most had deployment experience (n = 68; 75%). Some had hands-on experience with the relevant topic domains, with fewer having experience with Adjust Indirect Fire (n = 15; 16%) than with Conduct a Defense by a Squad (n = 35; 38%). Both Combat Arms (n = 28; 31%) and other Miltiary Occupational Specialties (MOSs) (n = 63; 69%) were represented.

Once assigned to their IMI variation, each Soldier was administered a pre-training test for their appropriate topic. Each topic had two alternate test forms that were matched question-to-question for content and difficulty. If a Soldier received Form A before training, he or she received Form B after training, and vice versa. Once the pre-test was complete, it was turned in to a data collector, the time was recorded, and Soldiers were allowed to begin training at their own pace with the IMI. At the completion of training, Soldiers completed a posttest. Finally, Soldiers were asked to fill out a user experience questionnaire; approximately 15 of the Soldiers were briefly interviewed about their learning experiences with the IMI following the session. The complete session required approximately 2 hours to complete.

RESULTS

Given that the tailored training variation was designed to provide learners the greatest flexibility to address their learning needs, the researchers expected the largest increase in pretest versus posttest scores for the two tailored training groups compared to the non-tailored familiarization and core/refresher IMI variations. Also, the researchers expected that learners in the tailored training group would have higher point gains from pretest to posttest for the less familiar content domain (Adjust Indirect Fire) compared to the more familiar content domain (Conduct a Defense by a Squad).

Prior Knowledge and Experience

To verify the assumption that the WLC Soldiers had different background knowledge and experience with the respective topic domains, their prior knowledge ratings were evaluated (see Table 3). Conduct a Defense by a Squad (M = 5.04, 'moderate' knowledge; SD = 2.19) rated higher than Adjust Indirect Fire (M = 3.30, 'none to little' knowledge; SD = 2.15), $F(1, 89) = 14.73$, $p < 0.001$. This finding supported the initial assumption concerning Soldiers' levels of familiarity with the two content domains. In addition, more Soldiers indicated having prior experience with the Conduct a Defense by a Squad domain (n = 35; 38%) compared to Adjust Indirect Fire (n = 15; 16%), $X^2(1, N = 91) = 5.72$, $p = 0.017$.

Table 3
Soldiers' Ratings of Prior Knowledge by Training Topic and Type of Needs-Focused IMI Training

Adjust Indirect Fire			Conduct a Defense by a Squad		
	Mean (SD)			Mean (SD)	
Fam	Core	Tailored	Fam	Core	Tailored
2.93 (1.86)	3.43 (2.24)	3.50 (2.39)	5.27 (2.15)	5.33 (2.09)	4.6 (2.35)

*Note: The self-ratings of prior knowledge were scaled as '1 to 3' = 'None to Little', '4 to 6' = 'Moderate', and '7 to 9' = 'Extensive'.

Reliability of Tests

Individual differences in background knowledge and experience may also have been reflected in the reliability metrics for both versions of the pretest and posttests administered. Table 4 presents the reliabilities for test versions A and B, administered as either pretests or posttests for Adjust Indirect Fire and Conduct a Defense by a Squad.

Table 4
Reliabilities for Pretests and Posttests

Test Version	**Adjust Indirect Fire**		**Conduct a Defense by a Squad**	
	Pretest	**Posttest**	**Pretest**	**Posttest**
A	0.63	0.81	0.84	0.81
B	0.79	0.87	0.84	0.78

Note: Unbiased parallel forms reliabilities are reported.

Reliability measures for the alternate tests were in the good to excellent range overall, with the exception of Adjust Indirect Fire at pretest. At posttest, the reliabilities the Adjust Indirect Fire tests were in the good to excellent range. It is likely that, given Soldiers' lack of familiarity with the Adjust Indirect Fire topic, the lower reliabilities at pretest may reflect increased guessing.

Training Time

The IMI were designed to take roughly an equivalent time to complete, with an exception for the diagnostic testing in the tailored training condition. The amount of time that Soldiers spent on the training was roughly equivalent (M = 12 to 16 minutes) across all conditions, after subtracting out the additional time for the diagnostic assessment in the tailored training condition (M = 15 to 18 minutes). The exception to this finding was the significantly higher time to complete core/refresher training (M = 23 minutes) in the Conduct a Defense by a Squad condition, $\beta_{standardized} = 0.35$, $t = 2.49$, $p = 0.016$, *partial* $r = 0.35$. This core/refresher IMI was focused on preparing urban fighting positions for the Javelin missile team.

Comparison of IMI Variations and Topic Domains

A repeated measures analysis of variance (ANOVA) was used to evaluate the relationship between pretest and posttest scores for the three variations of needs focused IMI, and the two topic domains. Prior knowledge, deployments, prior experience, and MOS (i.e., Combat Arms vs. Non-Combat Arms) were included as covariates. There was an overall significant within-subjects increase in scores between pretest and posttest for both Adjust Indirect Fire and Conduct a Defense by a Squad across the three IMI variations, $F(1, 81) = 14.67$, $p < 0.001$, $\eta_p^2 = 0.15$.[2] There was a mean 12% point increase from pretest to posttest for Adjust Indirect Fire, and a mean 10.7% point increase for Conduct a Defense by a Squad. Table 5 presents the mean pretest and posttest scores by topic domain and IMI type.

Table 5
Soldiers' Pretest and Posttest Mean Percentage Correct by Training Topic and Type of Needs-Focused IMI Training

Measures	**Adjust Indirect Fire** **Mean (SD)**			**Conduct a Defense by a Squad** **Mean (SD)**		
	Fam	Core	Tailored	Fam	Core	Tailored
Pretest Score (Mean % Items Correct)	39% (13%)	34% (16%)	48% (11%)	51% (13%)	51% (12%)	45% (15%)
Posttest (Mean % Items Correct)	47% (18%)	44% (21%)	66% (17%)	60% (12%)	63% (11%)	56% (13%)

There were three between-subjects effects identified. Soldiers who were in Combat Arms MOSs tended to have greater point gains compared to Soldiers who were not in Combat Arms MOSs, $F(1, 81) = 16.71$, $p < 0.001$, $\eta_p^2 = 0.15$. Soldiers' test scores for the more familiar domain (Conduct a Defense by a Squad) were higher overall ($M_{increase}$ = 7% points) compared to

[2] η_p^2 is partial eta-squared, a measure of effect size.

the test scores for the less familiar domain (Adjust Indirect Fire), $F(1, 81) = 7.24$, $p = 0.009$, $\eta_p^2 = 0.08$. Finally, there was an interaction of IMI type by topic domain, $F(2, 81) = 7.43$, $p = 0.001$, $\eta_p^2 = 0.16$. Table 6 summarizes the specific interaction effects.

Table 6
Summary of Interactions for the Repeated Measures ANOVA

Pre/Post Test	Topic	Variable	β	t	p	η_p^2
Pretest	Adjust Indirect Fire	Intercept	45.8	9.44	0.000	0.707
		Prior Knowledge (Self-Rating)	0.35	0.31	0.760	0.003
		Deployment	-7.31	-1.74	0.090	0.076
		Prior Experience	-8.72	-1.45	0.155	0.054
		Combat Arms MOS	**19.03**	**3.32**	**0.002**	**0.229**
		Familiarization	-4.07	-0.89	0.382	0.021
		Core/Refresher	**-9.60**	**-2.10**	**0.043**	**0.107**
		Tailored Training	--	--	--	--
	Conduct a Defense by a Squad	Intercept	37.05	6.65	0.000	0.525
		Prior Knowledge (Self-Rating)	0.59	0.58	0.566	0.008
		Deployment	1.88	0.38	0.703	0.004
		Prior Experience	0.30	0.07	0.943	0.000
		Combat Arms MOS	**12.69**	**2.79**	**0.008**	**0.163**
		Familiarization	2.53	0.58	0.568	0.008
		Core/Refresher	5.32	1.18	0.245	0.034
		Tailored Training	--	--	--	--
Posttest	Adjust Indirect Fire	Intercept	69.72	11.66	0.000	0.786
		Prior Knowledge (Self-Rating)	-1.27	-0.90	0.376	0.021
		Deployment	**-14.87**	**-2.88**	**0.007**	**0.183**
		Prior Experience	-12.21	-1.65	0.108	0.068
		Combat Arms MOS	**32.71**	**4.63**	**0.000**	**0.366**
		Familiarization	**-11.54**	**-2.04**	**0.049**	**0.101**
		Core/Refresher	**-15.24**	**-2.71**	**0.010**	**0.165**
		Tailored Training	--	--	--	--
	Conduct a Defense by a Squad	Intercept	49.95	8.83	0.00	0.661
		Prior Knowledge (Self-Rating)	0.64	0.62	0.54	0.010
		Deployment	4.91	0.99	0.33	0.024
		Prior Experience	-3.41	-0.81	0.43	0.016
		Combat Arms MOS	4.64	1.00	0.32	0.025
		Familiarization	2.54	0.57	0.57	0.008
		Core/Refresher	4.97	1.09	0.28	0.029
		Tailored Training	--	--	--	--

Note: Statistically significant interactions are in bold.

A difference was found among the three types of needs-focused IMI for the less familiar content domain (Adjust Indirect Fire). For the less familiar domain, tailored training was associated with higher posttest scores (i.e., 8 to 10% points), over both familiarization and core/refresher training. As a caveat, core/refresher scores for Adjust Indirect Fire were lower than tailored training at the pretest.

Finally, the effects of whether Soldiers had deployed or were in Combat Arms MOSs were associated with their posttest scores. Having at least one deployment was associated with lower posttest scores (a reduction of approximately12% points), whereas being in a Combat Arms MOS was associated with higher pretest (an increase of approximately 16% points), posttest scores (an increase of approximately 15% points).

There was no effect for training type for Conduct a Defense by a Squad, nor were self-ratings of prior knowledge associated with posttest scores for either content domain. Figure 5 summarizes the key results for topic domain and type of IMI design.

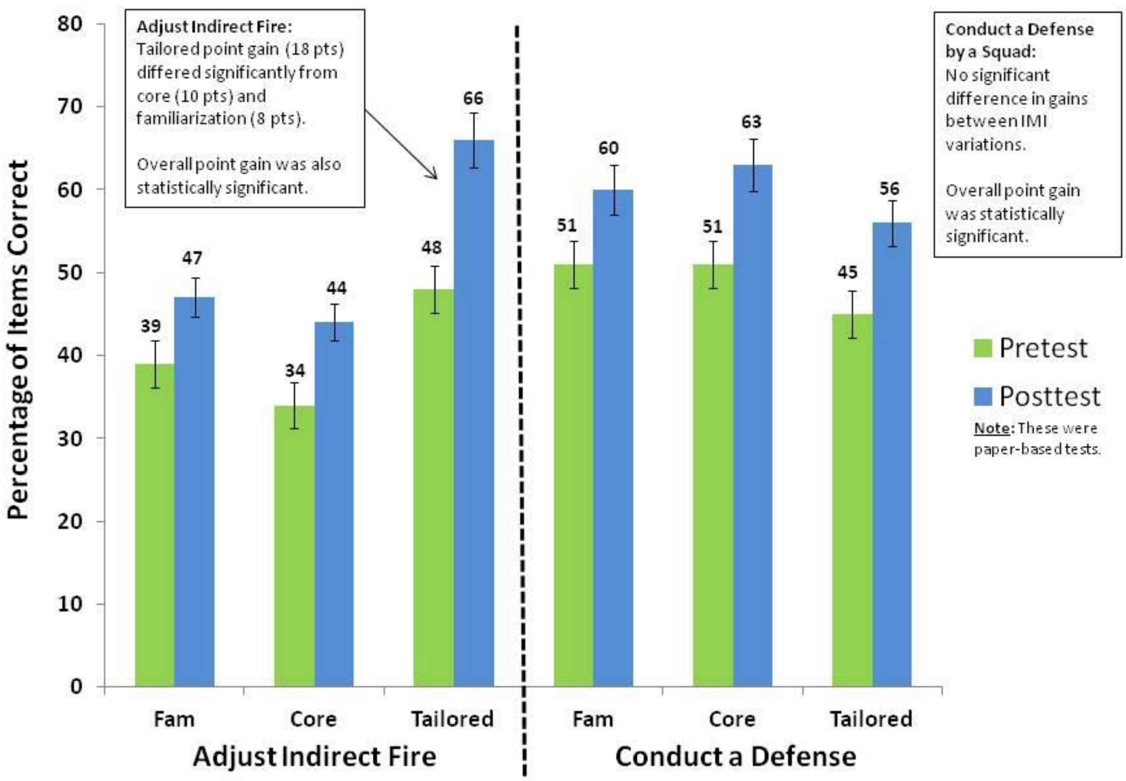

Figure 5. Pretest and Posttest Scores by Content Domain and Training Type

Due to small sample size, analyses were limited at the level of the tailored training IMI variations. Even so, we explored whether there were relationships between the diagnostic pre-assessment feedback Soldiers received and their selection of instructional content in the tailored training IMI condition. When looking only at the instructional path Soldiers selected, there did not appear to be a definitive relationship. However, when correlating training time within each learning path of the Adjust Indirect Fire IMI, there were statistical trends which suggested that

Soldiers may have spent more time on some sections of content (i.e., slowed down or paid more attention) given their individualized feedback they had received. For instance, Soldiers with lower diagnostic pre-assessment scores for ‘Formulate a Call for Fire’ were more likely to spend greater time in the ‘Fundamental Call for Fire Training’ section of the IMI, $r(11) = -0.61$, $p = 0.048$. In addition, there were marginally significant trends indicating a similar pattern for the other sections of the IMI: time spent on ‘Comprehensive Call for Fire and Adjust Indirect Fire Training’ trended with the ‘Determine/Transmit Elements of a Call for Fire’ scores, $r(16) = -0.48$, $p = 0.06$; and time spent on ‘Fundamental Adjustment Training’ was associated with diagnostic pre-assessment ‘Adjust Rounds on Target; End the Mission’ scores, $r(12) = -0.52$, $p = 0.081$. With a larger sample size, a clearer picture would likely emerge of how Soldiers were using the diagnostic assessment feedback they received in the Adjust Indirect Fire IMI condition. Although the overall statistical result for the tailored training variation of Adjust Indirect Fire was positive, to determine how diagnostic feedback may have influenced Soldiers to attend more carefully to recommended content would require additional data.

The associations between training time and diagnostic feedback for the Conduct a Defense by a Squad group were less apparent. For the section of diagnostic assessment labeled ‘Provide effective/adequate fields of fire,’ higher scores were associated with more time spent on the ‘Selecting Weapons Positions and Controlling Fires’ section of the IMI, $r(17) = 0.46$, $p = 0.032$. A similar correlation was noted between the ‘Employ fire control measures effectively’ section of the diagnostic assessment and the ‘Selecting Weapons Positions and Controlling Fires’ section of the IMI, $r(17) = 0.43$, $p = 0.044$. There were no marginal trends noted for the other variables, associating training time with diagnostic pre-assessment feedback. The diagnostic feedback provided to Soldiers did not appear to be as influential in the Conduct a Defense by a Squad (more familiar) IMI condition as it was in the Adjust Indirect Fire (less familiar) IMI condition.

Learner Experiences and Feedback

IMI is effective if learners perceive value in using it to learn. In order to explore Soldiers’ experiences using the IMI, the researchers developed and administered a user experience questionnaire. This questionnaire was administered after all IMI training and testing was complete.

Initially, 39 items were included on the questionnaire. An exploratory factor analysis was conducted, reducing the 39 items to 31 items in six factors, accounting for 58% of variance.[3] Factors were selected if they contributed at least 3% to the explained variance. While the sample size was small ($N = 91$), the tests for sampling adequacy and correlation were good: Kaiser-Meyer-Olkin = 0.84; Bartlett’s Test $X^2(df = 630) = 2{,}339.023$, $p < 0.001$. Item level means and standard deviations are reported in Appendix A.

[3] The factor analysis extraction method was Alpha factoring with Promax (Kappa = 4) rotation. Alpha factoring maximizes the reliability coefficient of items to combine them into factors. Promax rotation is an orthogonal rotation that is less strict than Varimax, allowing for oblique adjustments following an initial orthogonal solution (Kline, 2013).

Factor scores were calculated. Table 7 summarizes the results for each factor measured on the user experience questionnaire for each IMI variation by content type. The questionnaire used Likert style response options, ‘Strongly Disagree’ (1) to ‘Strongly Agree’ (5).

Table 7
User Experience Factor Scores by Needs-Based IMI Variation and Type of Content.

User Experience Factors and Definitions	User Experience Scores Mean (SD)					
	Adjust Indirect Fire			Conduct a Defense by a Squad		
	Fam *n*=14	Core *n*=14	Tailored *n*=16	Fam *n*=15	Core *n*=15	Tailored *n*=17
Quality of Learning Experience (α = 0.91)						
• Learners’ overall view of their learning experience with the IMI.	3.79 (0.75)	3.55 (0.82)	3.79 (0.65)	4.03 (0.81)	3.92 (0.62)	3.61 (0.77)
Quality of Design and Content (α = 0.86)						
• Learners’ overall impression of the IMI design and content.	4.19 (0.46)	3.96 (0.54)	3.98 (0.56)	4.23 (0.65)	4.08 (0.50)	4.02 (0.50)
Continuity of Topics (α = 0.85)						
• Learners’ perceived connections between topics in the IMI.	4.14 (0.47)	3.93 (0.57)	4.03 (0.48)	4.33 (0.57)	4.15 (0.55)	3.95 (0.52)
Credible Examples (α = 0.85)						
• The examples provided in the IMI were realistic and lifelike.	4.04 (0.54)	3.88 (0.54)	4.07 (0.58)	4.16 (0.53)	4.10 (0.49)	3.95 (0.47)
Focus and Relevance (α = 0.77)						
• Checks on learning, etc., were perceived to be on topic and relevant to the learning task.	4.07 (0.49)	3.83 (0.74)	3.94 (0.73)	4.27 (0.54)	4.07 (0.58)	4.12 (0.44)
Tracking Progress (α = 0.77)						
• Learners were able to track their progress within the IMI to stop/resume training.	4.03 (0.75)	3.64 (0.77)	3.66 (0.91)	3.77 (0.82)	3.83 (0.88)	3.65 (0.77)

Given the small sample size on which the factor analysis was based, the resulting factor structure may not be optimal. That said, the factor structure may be practically useful for evaluating user experiences of IMI. The questionnaire items and factor structure would likely benefit from continued refinement.

The user experience scores were compared between the three types of needs-focused IMI and the two types of content domains using an analysis of variance. There were no significant differences found. This finding suggests that user experiences were similar across the three IMI variations and two topic domains.

To explore the relationships between pretest and posttest scores and user experiences, a correlation analysis was conducted. Soldiers who tended to have higher scores on the pretest also had higher quality of learning experience ratings, $r(91) = 0.23$, $p = 0.03$, suggesting that prior knowledge was being used to evaluate the quality of the learning materials. In addition, Soldiers with Combat Arms MOSs were also more likely to have higher quality of learning experiences, $r(91) = 0.35$, $p = 0.001$, indicating that they perceived the domain content to be more relevant. Likewise, Soldiers with higher prior knowledge of the topics also rated their learning experiences higher than those who did not, $r(91) = 0.34$, $p = 0.001$. Soldiers with higher prior knowledge also perceived greater continuity to the topics covered in the IMI, $r(91) = 0.27$, $p = 0.010$, and greater relevance to the checks-on-learning and other assessments used within the IMI, $r(91) = 0.24$, $p = 0.024$. No other variables were significantly correlated.

DISCUSSION

Soldiers' learning needs vary given their career path, career point, prior knowledge, and experiences. These differences can affect how well Soldiers learn in specific educational and training contexts, or with particular subject matter and media (TRADOC, 2011). While face-to-face instruction allows an instructor and student to address specific learning needs, the IMI used in distributed learning situations is often designed to reach a large audience. In reaching a large audience, it becomes necessary to include more generic content than face-to-face instruction. However, there are design features that can be incorporated into IMI to better tailor content to the learning needs of specific audiences and individual learners. This research was intended to address how individual differences between learners can best be accounted for when designing IMI for audiences that are diverse in background knowledge and experience.

ARI researchers conducted an experiment to evaluate three different needs-focused IMI designs in relation to two topic domains, one familiar to our audience of learners and one unfamiliar. One of the needs-focused IMI designs incorporated design features to tailor the training to individual needs; the other two IMI designs were not tailored. In past research, Dyer, Singh, and Clark (2005) found that Soldiers with less prior knowledge tended to benefit from having more structured training, whereas learners who had more prior knowledge benefitted from being able to selectively adapt training to their own needs. This current research designed IMI to provide options to learners, using a flexible approach to both guide novice learners as well as provide a means for more experienced learners to navigate to content relevant to them. The tailored training variation was the most comprehensive in terms of the content and structure provided to learners, whereas familiarization IMI focused on breadth of content and refresher/core IMI focused on depth of content.

It was hypothesized that tailored training IMI would be associated with the largest increase in scores between pretest and posttest compared to the non-tailored IMI variations, regardless of whether the topic domain was more or less familiar. It was also hypothesized that Soldiers in the less familiar topic condition would benefit more from tailored training than Soldiers in the more familiar topic condition.

Based on the results, the tailored training IMI was most beneficial to learners in the less familiar content domain, but it did not appear to have any impact over non-tailored variations in the more familiar content domain. This finding was in accord with Dyer et al.'s (2005) research. Among the many potential options available for designing tailored training, the approach used here was intended to be a simple and straightforward way to incorporate tailoring techniques into needs-focused IMI. The design allowed for a higher degree of learner autonomy than other adaptive training designs that rely on complex algorithms to select and sequence training for learners. Moreover, many of the design features that supported learner autonomy—such as chunked content to support flexible navigation—were incorporated into the non-tailored variations. For more knowledgeable learners, those design features may have afforded a means to tailor their learning experience even in the non-tailored IMI variations.

Experimental Test of the IMI and Topic Variations

In the experimental test of the needs-focused IMI, the results for Adjust Indirect Fire, which was the less familiar task, were as expected. In the Adjust Indirect Fire groups, all Soldiers showed improved performance, with Soldiers in the tailored training group showing much greater improvement over those in the non-tailored familiarization and core/refresher IMI groups. However, the results for Conduct a Defense by a Squad did not follow this pattern. For Conduct a Defense by a Squad, all three needs-focused IMI conditions were associated with roughly equivalent improvement in test scores.

One possible explanation for this difference between the Adjust Indirect Fire and Conduct a Defense by a Squad concerns the ways in which the Soldiers were navigating through the IMI. What seemed to be happening more frequently in the Conduct a Defense by a Squad group was that Soldiers tailored their learning experience by taking advantage of the design features incorporated for navigation into all the IMI conditions. Based on the researchers' observations, Soldiers seemed to be using the content headings and their own prior knowledge of the domain to track down novel information more quickly, navigating around—or quickly through—sections of content that were already familiar to them. This observation was supported anecdotally by feedback from participants following the experiment.

With diagnostic testing and feedback, the tailored training for Adjust Indirect Fire may have provided a similar support to learners who were less knowledgeable. This support perhaps enabled learners to better tailor their learning experience to their identified needs without having prior knowledge on which to rely. That said, another possible explanation concerns the relative complexity of the tasks. Adjust Indirect Fire, while a less familiar task, was also more sequential in structure than Conduct a Defense by a Squad. The particular ways in which the design features were implemented may have better supported learning of a more sequential and clearly structured task. Even so, additional research may be necessary to identify the precise mechanisms associated with this effect.

User Experiences with the IMI

When Soldiers completed the experiment, they filled out a user experience questionnaire to evaluate the needs-focused IMI. On the basis of those responses, an exploratory factor analysis was conducted to identify the critical factors supporting their learning experience with IMI. There were no significant differences between the familiarization, core/refresher, and tailored IMI variations in terms of Soldiers' learning experiences. However, the targeted audience tended to rate their learning experience with the IMI more positively. The items and factors identified for the user experience questionnaire may be useful in future research to evaluate learner experiences and to prioritize areas for improvement in existing IMI. The specific items and factors are presented in Appendix A.

IMI Design and Development

When developing IMI for this research, certain design principles were particularly useful for tailoring content to individual learners' needs. For example, a hierarchical and chunked organizational structure enabled users to quickly address a single topic in relation to other topics covered and to navigate through the IMI. Segmenting and presenting content in this way may also allow learners to take breaks and resume learning later with reduced disruption (Mayer, 2005). Soldiers interviewed said that it is important that IMI be designed to allow learners to take breaks from the IMI and later resume it, given the many competing on-the-job demands.

Another design principle of the IMI applied to this research was the use of evaluation and feedback for each task step, similar to the usual checks-on-learning approach used by the Army, but the evaluation and feedback focused more on the set of steps to execute a complete task. The intention was to support learners in developing a sequential understanding of the task, providing rationale for each step and how those steps interrelate. Further, the structure of the task steps and decision processes at each point was a central focus. This was easy to do for a sequential task like Adjust Indirect Fire; however, it was more difficult when considering the multiple simultaneous subtasks and decision points in Conduct a Defense by a Squad. The Conduct a Defense by a Squad IMI modules required more articulated structures in order to capture the various narrative threads of the task and to address learners' particular needs. So, although the Conduct a Defense by a Squad task was more familiar to Soldiers, it also required the IMI developed to be more complex in its design and selection of content.

Finally, a diagnostic assessment and individualized feedback in the tailored training condition was used to assist learners in identifying a path through the IMI that would be optimized for their learning needs. By providing detailed feedback to learners about the topic areas in which they had difficulty and allowing them to make informed decisions about how they would navigate the IMI, it was possible to apply tailored training principles in IMI without relying on a learning management system. While a learning management system is often required for certain types of adaptive training, the approach used in this research may allow for tailoring within even less complex and standalone types of IMI.

It was determined that only 30% of the existing Army IMI reviewed was reusable in the way developers had intended (see Blankenbeckler et al., 2014). Therefore, 70% of the IMI used in the experiment was developed from a cold start. This suggests that the Army would benefit from a continued focus on IMI research and the need to reuse IMI across a variety of learning contexts (i.e., Sharable Content Object Reference Model; DoD, 2011). There are many excellent examples of Army IMI that demonstrate solid instructional design and application of learning science. However, few are currently configured for or are available in a format that facilitates modification and reuse to produce learning materials for different courses and audiences. When seeking to modify and reuse existing IMI, this research encountered a number of challenges. Often, source files were difficult to track down, the software in which the original IMI was designed was outdated, and uniforms, doctrine, etc., had sometimes changed. In order to reuse IMI, workarounds were often necessary. As an example, digitally recording audio and video off the My Training Tab (MT2) site allowed the designers to produce an editable file. This was a more effective approach than attempting to modify incomplete or outdated source files.

Unfortunately, trying to modify and reuse existing IMI was more time consuming than developing IMI from a cold start.

Researchers have demonstrated that designing and implementing effective IMI requires designers to plan how to present content in advance. During this planning process, consideration must be given to the cognitive capabilities of the target audience (i.e., prior knowledge, attention, working memory, cognitive load, etc.), as well as, determining which design principles (i.e., segmentation, scaffolding, highlighting, personalization, etc.) will be most useful given these potential individual differences within the target audience.

The most serious problem that can emerge from ineffective multimedia design is cognitive overload (Mayer & Moreno, 2003). Most often, cognitive overload results from individuals engaging in too much extraneous processing (Mayer, 2008). Meaningful learning requires substantial amounts of mental effort and intentional processing, but due to limited cognitive resources (e.g., working memory and/or attention), the processing demands evoked by multimedia can exceed individuals' processing capabilities (Mayer & Moreno, 2003). To be a successful instructional tool, IMI and multimedia systems must be adaptable and account for differences in cognitive capacities among learners (Gyselinck et al., 2000). For example, animations can reduce extraneous processing and increase interactivity; however, some researchers have proposed that including animations in multimedia presentations can impede learning by creating false perceptions about the ease of learning from multimedia (i.e., illusions of understanding; Paik & Schraw, 2013). If individuals think something is easy to learn, they may not invest as much effort into learning.

Conclusions

Tailored and adaptive training techniques have been applied in some existing Army IMI. Often, these are complex techniques that automate the process of down-selecting content to focus only on that which is most appropriate to an individual learner's background knowledge and experience. While these approaches can be very effective, they frequently require a large data set, or are costly to develop (Blankenbeckler et al., 2013). When the audience for a particular IMI is large, it is reasonable to make a large investment in its development. However, for a more narrowly defined audience, complex implementations of tailored or adaptive training may not be viable (Blankenbeckler et al., 2014).

Nonetheless, streamlined and more cost-effective IMI designs may be applied to address the learning needs of narrowly defined audiences, targeting what has been described in the Army Learning Model (ALM) as *point of need*, which has been described by two perspectives (TRADOC, 2011). The first perspective focuses on the technologies used to provide instruction *where and when* needs may arise. These technologies include desktop or laptop computers, tablets, smartphones, or other technologies that serve to distribute or access digital instructional materials. The second perspective on point of need focuses on the *content and design* of the instruction itself. As each Soldier comes to training with unique professional experiences, background knowledge, and job-specific requirements, their learning needs will tend to differ. These differences can affect how well Soldiers learn with regard to specific educational and training contexts, or with particular subject matter and media (TRADOC, 2011). Research is needed to address how individual differences between learners can best be accommodated when designing IMI for audiences that are diverse in background knowledge and experiences, yet share a common learning need.

Continued research and innovation is essential for determining how to best develop IMI that can be modified and reused across different learning contexts and for different learning needs. The design principles identified by this research provide a simple and effective means to apply tailored training techniques within IMI that do not require complex programming and high bandwidth features. This streamlined approach to needs-focused IMI design may be applicable for the Army and other branches of the military. When learners are less familiar with a topic domain, it may be useful to provide them with an understandable navigational structure, including clearly labeled chunks of content, to supplement their understanding of the domain and enable them to select an appropriate learning path in order to tailor their learning experience. Using diagnostic assessments with individualized feedback may further assist learners in discriminating between personally relevant and irrelevant content while learning, even if they do not yet have extensive domain knowledge. When learners are more familiar with a topic, the navigational structure appeared to assist them in seeking novel information. In this regard, the information seeking behavior observed was similar to what has been observed in other contexts when comparing novices to more knowledgeable learners (Kalyuga, 2005).

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Acronyms

1SG	First Sergeant
ALM	Army Learning Model
ANOVA	Analysis of Variance
ARI	Army Research Institute for the Behavioral and Social Sciences
CAT	Computer Adaptive Testing
COL	Colonel
CPT	Captain
DOTD	Directorate of Training and Doctrine
FDC	Fire Direction Center
FCoE	Fires Center of Excellence
E-4	Paygrade for Specialist/Corporal
E-5	Paygrade for Sergeant
IMI	Interactive Multimedia Instruction
LTC	Lieutenant Colonel
MCoE	Maneuver Center of Excellence
MT2	My Training Tab
MOS	Military Occupational Specialty
NCO	Noncommissioned Officer
TRADOC	U.S. Army Training and Doctrine Command
WLC	Warrior Leader Course

APPENDIX A

USER EXPERIENCE QUESTIONNAIRE FACTORS AND ITEMS

User Experience Questionnaire Factors and Items

User Experience Factors	User Experience Scores Mean (SD)					
	Adjust Indirect Fire			Conduct a Defense by a Squad		
	Fam *n*=14	**Core** *n*=14	**Tailored** *n*=16	**Fam** *n*=15	**Core** *n*=15	**Tailored** *n*=17
1. Quality of Learning Experience (α = 0.91)						
• I would recommend that this IMI be made available to all junior NCOs.	4.07 (0.92)	3.64 (1.08)	3.81 (0.83)	4.27 (0.70)	4.00 (1.00)	3.71 (0.77)
• I would use this IMI to refresh my skills at a later date.	3.93 (0.83)	3.64 (1.01)	3.94 (0.68)	4.27 (0.88)	3.93 (0.88)	3.88 (0.99)
• I feel I have a better understanding of the task after completing the IMI.	3.86 (1.03)	3.57 (0.94)	4.00 (0.82)	4.07 (0.96)	4.27 (0.59)	3.71 (0.77)
• I preferred this IMI to others I have used in the past.	3.43 (1.09)	3.57 (1.02)	3.44 (0.73)	4.20 (0.94)	3.67 (0.90)	3.47 (0.87)
• The IMI interactively helped my learning process.	3.86 (1.03)	3.71 (0.73)	3.88 (0.62)	3.80 (0.86)	4.07 (0.59)	3.76 (0.83)
• On the basis of this IMI, I could execute the task as a combat leader.	3.64 (1.01)	3.21 (1.19)	3.63 (1.20)	3.60 (1.35)	3.73 (0.96)	3.35 (1.22)
• I feel this IMI was able to meet my individual learning needs.	3.71 (0.83)	3.50 (0.94)	3.88 (0.96)	4.00 (0.76)	3.80 (0.86)	3.35 (0.93)
Overall	**3.79 (0.75)**	**3.55 (0.82)**	**3.79 (0.65)**	**4.03 (0.81)**	**3.92 (0.62)**	**3.61 (0.77)**
2. Quality of Design and Content (α = 0.86)						
• The displays on the screen were clear and legible.	4.50 (0.52)	4.29 (0.61)	4.31 (0.60)	4.53 (0.64)	4.33 (0.62)	4.06 (0.75)
• The graphics supported the material being presented.	4.35 (0.50)	4.14 (0.53)	4.06 (0.57)	4.40 (0.63)	4.13 (0.83)	4.18 (0.64)
• Prompts and cues in the IMI assisted me in navigating through the material.	4.07 (0.83)	4.00 (0.68)	3.88 (0.62)	4.13 (0.92)	4.27 (0.46)	4.06 (0.66)
• The information presented seemed accurate and doctrinally correct.	4.14 (0.53)	4.07 (0.62)	4.06 (0.77)	4.40 (0.63)	3.87 (0.92)	4.23 (0.56)
• I felt like I was in control of my learning process.	4.21 (0.80)	3.57 (1.02)	3.88 (0.72)	4.27 (0.88)	4.00 (0.65)	3.65 (0.93)
• The information presented seemed up-to-date.	4.14 (0.53)	4.07 (0.62)	4.13 (0.72)	4.20 (0.68)	4.13 (0.83)	4.18 (0.81)
• I could easily track where I was in the IMI.	3.93 (0.92)	3.86 (0.66)	3.63 (1.09)	3.80 (1.26)	4.07 (0.70)	3.76 (0.83)
• Uniforms, practices, and equipment were up to date.	4.14 (0.53)	3.64 (0.84)	3.94 (0.77)	4.07 (1.03)	3.87 (0.99)	4.06 (0.75)
Overall	**4.19 (0.46)**	**3.96 (0.54)**	**3.98 (0.56)**	**4.23 (0.65)**	**4.08 (0.50)**	**4.02 (0.50)**
3. Continuity of Topics (α = 0.85)						
• There was a good connection between the topics.	4.29 (0.61)	3.79 (0.70)	4.00 (0.52)	4.33 (0.72)	4.20 (0.56)	3.88 (0.70)
• The sequence of topics seemed to build on each other.	4.21 (0.58)	3.71 (0.83)	3.88 (0.72)	4.20 (0.86)	4.13 (0.64)	3.71 (0.69)

• IMI content was grouped to facilitate learning.	4.14 (0.66)	4.07 (0.62)	4.06 (0.57)	4.33 (0.49)	4.20 (0.68)	4.06 (0.66)
• There was a clear focus of topics in the IMI.	4.43 (0.65)	4.07 (0.62)	4.13 (0.62)	4.53 (0.52)	4.13 (0.74)	4.00 (0.79)
• Grouping of content allowed me flexibility in accessing material.	3.64 (0.50)	4.00 (0.68)	4.06 (0.57)	4.27 (0.88)	4.07 (0.70)	4.12 (0.60)
Overall	**4.14 (0.47)**	**3.93 (0.57)**	**4.03 (0.48)**	**4.33 (0.57)**	**4.15 (0.55)**	**3.95 (0.52)**
4. Credible Examples (α = 0.85)						
• Examples contributed to my learning.	4.07 (0.92)	3.86 (0.66)	4.13 (0.62)	4.20 (0.68)	4.27 (0.59)	4.06 (0.83)
• The examples made sense.	4.21 (0.43)	4.00 (0.55)	4.19 (0.54)	4.20 (0.68)	4.20 (0.56)	4.06 (0.66)
• I learned a lot about the task.	3.71 (0.91)	3.50 (0.76)	3.88 (0.81)	4.00 (0.93)	4.07 (0.80)	3.82 (0.64)
• Examples were presented in a realistic mission context.	4.21 (0.58)	4.00 (0.68)	4.25 (0.58)	4.00 (0.76)	3.93 (0.80)	4.06 (0.56)
• Repetition of examples was helpful.	4.07 (0.62)	4.00 (0.68)	3.94 (0.68)	4.20 (0.68)	4.07 (0.59)	4.12 (0.78)
• Topics were of the right length to allow me to complete without needing a break.	3.93 (0.62)	3.93 (0.73)	4.06 (0.68)	4.33 (0.49)	4.07 (0.80)	3.59 (0.80)
Overall	**4.04 (0.54)**	**3.88 (0.54)**	**4.07 (0.58)**	**4.16 (0.53)**	**4.10 (0.49)**	**3.95 (0.47)**
5. Focus and Relevance (α = 0.77)						
• Questions asked within the IMI were reasonable and helped me to understand the topic.	4.07 (0.73)	3.71 (0.91)	3.81 (0.75)	4.20 (0.76)	4.00 (0.76)	4.00 (0.71)
• The questions asked within the IMI focused on what was being taught.	3.93 (0.62)	3.93 (0.83)	3.94 (0.75)	4.33 (0.62)	4.20 (0.68)	4.12 (0.49)
• The overall focus of the IMI was right on target.	4.21 (0.58)	3.86 (0.86)	4.06 (0.77)	4.27 (0.59)	4.00 (0.85)	4.24 (0.66)
Overall	**4.07 (0.49)**	**3.83 (0.74)**	**3.94 (0.73)**	**4.27 (0.54)**	**4.07 (0.58)**	**4.12 (0.44)**
6. Tracking Progress (α = 0.77)						
• If I took a break during the learning process, I could easily resume learning when I returned.	4.14 (0.77)	3.79 (0.80)	3.75 (0.93)	3.93 (0.96)	3.93 (1.10)	3.65 (0.86)
• I would be able to take breaks during the learning process and keep track of my progress.	3.93 (0.83)	3.50 (0.96)	3.56 (0.96)	3.60 (0.91)	3.73 (0.80)	3.65 (0.79)
Overall	**4.03 (0.75)**	**3.64 (0.77)**	**3.66 (0.91)**	**3.77 (0.82)**	**3.83 (0.88)**	**3.65 (0.77)**